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Reducing the back overuse-related risks in alpine ski racing: let's put research into sports practice

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It is well recognised in alpine ski racing (ASR) that the risk of traumatic injuries is high.[1] Yet, so far the nature and causation of ASR-related back overuse injuries have received little attention.[2] During adolescence, competitive alpine skiers are already suffering from more prevalent spinal disc degeneration and more severe back pain than age-matched controls.[3] Factors previously suggested as being important components of mechanisms leading to overuse injuries of the back are: (1) adverse trunk kinematics including a combined occurrence of frontal bending, lateral bending and torsion,[4] (2) high ground reaction forces,[4] and (3) excessive exposure to low-frequency whole-body vibrations (WBV) (~4–10 Hz; ie, frequencies close to resonant frequency of the spine; known to be the most damaging to spinal structures).[5 6] All of these factors have been demonstrated to be inherent parts of ASR and occur in different combinations and intensities.[4 5] Despite applying quite radical equipment and course modifications, previous studies discovered the ASR-specific overall trunk kinematics to be unchangeable.[7 8]

LOW-FREQUENCY WBV IN COMBINATION WITH HIGH GROUND REACTION FORCES: AN OVERLOOKED RISK FACTOR?

Regarding low-frequency WBV exposure in combination with high ground reaction forces, recent studies revealed significant differences in the power spectral density (ie, the signal's power distribution over frequency) and the root mean square of low-frequency weighted vibrations (RMS_{ISO}; ie, acceleration data filtered according to the international standard ISO 2631) between different alpine skiing techniques and ASR competition disciplines.[5 6] The extent of the skis skidding sideways was discovered to be associated with the occurring WBV (~8–35 Hz) and acting forces.[6] In many skiing situations, the WBV exposure massively exceeded the limits set by the European Directive 2002/44/EC for health and safety.[6] Moreover, in ASR, acting ground reaction forces can reach up to 2.89 times body weight.[4] Accordingly, any measure generally reducing the WBV exposure and/or the ground reaction forces while skiing should be applied.[5 6]

More specifically, one could hypothesise that measures affecting the ski–snow interaction might be helpful for reducing the low-frequency WBV and acting ground reaction forces; thus, minimising athletes' overall load exposures. As an exemplary measure for affecting the ski–snow interaction, and thereby influencing the low-frequency vibrations that act on the skiers' spines, different 'snow preparation techniques' are further elaborated hereinafter.

PUTTING RESEARCH INTO SPORTS PRACTICE: 'SNOW PREPARATION TECHNIQUES' AS A PREVENTION MEASURE FOR OVERUSE INJURIES OF THE BACK IN ASR?

During a biomechanical field experiment in slalom, the differences in WBV exposure and ground reaction forces (ie, representing the overall mechanical load) between a well-packed, machine-groomed artificial snow surface and the same preparation procedure in combination with high-pressure water injection (performed with a World Cup ASR typical injection bar system) were compared. Methods are further described in online supplementary box 1.

When skiing on the water-injected slalom course, the RMS_{ISO} value (ie, the exposure to vibrations acting on the spine) was 5.7% higher than on the course that was machine groomed only (table 1). The average ground reaction forces were found to be unaffectedly high on both courses.

In view of these findings, and knowing that in ASR short-term WBV (shocks), particularly in combination with high ground reaction forces, can result in even more adverse loading conditions/higher health risks, the application of water injection in addition to a superior machine-groomed preparation should be reconsidered, and a standardisation by international competition rules should be discussed. Special care should be applied during training and competitions of youth athletes on such snow conditions, since their bodies are in stages of maturation and, therefore, especially sensitive to an accumulation of the adverse spinal loading. Moreover, as a result of less developed skills, younger athletes may skid more sideways when skiing on water-injected slopes; a factor known to increase the WBV exposure even further.[6] Finally, omitting or restricting water-injected slopes could induce the ski industry to construct less aggressive skis and ski boots, which might be beneficial for the purpose of injury prevention, in general.[1]

WHERE TO GO FROM HERE?

Future research on back overuse injuries in ASR should focus more specifically on low-frequency WBV in combination with high ground reaction forces, as these are most likely the only two variables that can be modified by external prevention measures.[5 7 8] As illustrated in this study, one such measure might be found in 'snow preparation techniques' and

Table 1 Descriptive and inferential statistics of the average total ground reaction forces (*F*tot) and the root mean square accelerations (*RMS*ISO) that act on the lower back while slalom skiing. Values are reported for two different snow conditions (machine-groomed vs water-injected course), and are based on the data of seven competitive youth alpine skiers (36 slalom turns per athlete and course)

	Mean±SD		T-test	
Parameter	Machine-groomed slalom course	Water-injected slalom course	P values	Cohen's d
RMS_{ISO} (m/s^2)	10.22±0.73	10.80±0.90	0.039*	–0.992
F_{tot} (n/BW)	1.49±0.31	1.48±0.30	0.862	0.087

*P<0.05: level of significance.
BW, body weight.

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corresponding safety regulations. Turning research into action could mean: (1) in (youth) ASR, additional water injection should only be used with care, or (2) if the actual snow conditions are for any reason demanding (eg, introduce a higher amount of skidding and, therefore, higher WBV exposure[6]), one should reduce the number of skiing days, or at least the number of runs per skiing day under such conditions. In the future, body-worn sensor technology might help generate a more profound understanding of the dose–effect relation of low-frequency WBV and force exposure, and to keep ASR-related training loads at a healthy level.

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